

# Auditory rehabilitation on congenital deafness pediatric patients after cochlear implantation

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**ABSTRACT**

**Purpose:** This study aimed to determine the effect of auditory rehabilitation in children after 1 year of cochlear implantation and related factors. **Method:** Retrospective and prospective descriptive study was conducted at the Ho Chi Minh City Ear-Nose-Throat Hospital from January 2018 to April 2020. Determine the effect of auditory rehabilitation in children according to the CAP scale at 3, 6, 9 and 12 months after implant activation. **Result:** Thirty-nine children with congenital deafness who received cochlear implants were included in this study. At 1 year after CI, all children reached the CAP score at 5 points or more and 87.18% of cases had CAP score from 6 to 7 points. The mean CAP scores at 12 months after CI were  $6.18 \pm 0.64$  points. This study found out the effects of number of CI, time of learning auditory rehabilitation and family cooperation on CI outcome. Children with bilateral CI were more successful in auditory performance than children with unilateral CI (mean CAP scores:  $6.38 \pm 0.62$  vs  $6.04 \pm 0.64$ ). In the group of children with cooperative parents, children who studied at class for "5 hours per week or more" had better auditory rehabilitation than those who studied for fewer hours (mean CAP scores:  $6.25 \pm 0.64$  vs.  $6.20 \pm 0.68$ ). **Conclusion:** CAP score of pediatric patients tend to increase significantly one year after the operation, almost reach the normal score.

**Keywords:** hearing loss, congenital deafness, cochlear implantation (CI), auditory rehabilitation.

**1. INTRODUCTION**

Hearing loss is a most common human sensory disability, which significantly affects social functions and psychological development of the patients. Hearing loss which occurs on children poses a huge limitation on their future. Hearing loss affects negatively on 28 million American patients. The prevalence of childhood hearing loss is about 1 to 3 per 1000 children, and 40 to 50 percent of elderly over 75 suffer from this condition. According to World Health Organization, approximate 5 percent of global population are living with hearing loss, estimating at 430 million people including 34 million

children. South Asia is the region that faces the highest incidence of childhood hearing loss (3.4%), followed by the Asia-Pacific (2%). In Vietnam, a survey in 2003 hosted by the Ministry of Labor, War Invalids and Social Affairs found 663 thousand children living with disabilities, accounted for 2.4% children population. The three most common childhood disabilities regarding movement (29%), neuronal dysfunction (17%), and deafness (17%) (WiaSa Ministry of Labor & United Nations Children's Fund, 2004). According to another national report in 2009, it is estimated that 3 million Vietnamese (3.8% population) suffered from deafness, 0.5% of which are children (The United Nations Population Fund, 2009).

Since the 1960s, cochlear implantation (CI) has been known thanks for the development of artificial unilateral cochlear device. In the 1970s, bilateral CI was invented, resulting in the establishment of modern implant centers worldwide, such as in the US, France, Switzerland, and Australia. As a historical milestone in otology, Graeme Clark performed the first bilateral CI in Australia. In 1988, the first implantation in Vietnam was operated in Ho Chi Minh City Ear-Nose-Throat Hospital. Since then, over 500 operations have been successfully performed, resulting in auditory rehabilitation for the patients, improving their ability in speaking, learning and social functioning.

Realizing the significant benefit of the CI on rehabilitating language function for pediatric patients and reducing disease burden on society, it is necessary for in-depth research regarding this type of operation. Therefore, this study was conducted aimed to investigate the post-surgery linguistic improvement, and then recommend reference point of time for monitoring the rehabilitation after CI.

## 2. MATERIALS AND METHODS

### **Study design**

This is a case-series report on pediatric patients in Ho Chi Minh City Ear-Nose-Throat Hospital. Included patients were post-surgery monitoring to evaluate their auditory rehabilitation at four points of time, three months, six months, nine months and one year after the operation.

### **Study subjects**

Patients at the age under 12 with congenital deafness, who have been experienced a uni- or bilateral CI from January 2018 to April 2020 in the hospital was recruited. Total sampling technique was applied to invite 39 eligible cases to participate in the study. Entire 39 parents agree to have their child evaluated after his/her CI.

### **Study instrument**

The auditory rehabilitation was evaluated by using a scale called categories of auditory performance (CAP). CAP scale has been used widely to rate outcomes from pediatric cochlear implantation in everyday life. It varies from more technical metrics in that it can be used and understood by non-specialist professionals as well as parents. It includes an eight-category scale on which children's growing hearing talents can be assessed in order of increasing difficulty. The categories are:

- 0 = Displays no awareness of environmental sounds;
- 1 = Awareness of environmental sounds;
- 2 = Responds to speech sounds;
- 3 = Recognizes environmental sounds;
- 4 = Discriminates at least two speech sounds;
- 5 = Understands common phrases without lipreading;
- 6 = Understands conversation without lipreading with a familiar talker;
- 7 = Can use the telephone with a familiar talker.

### **Data analysis**

Collected data was entered into Microsoft Excel and was analyzed by using Stata 16.0 software. Descriptive statistics was performed on average CAP score at four points of time after CI.

### **Ethics statement**

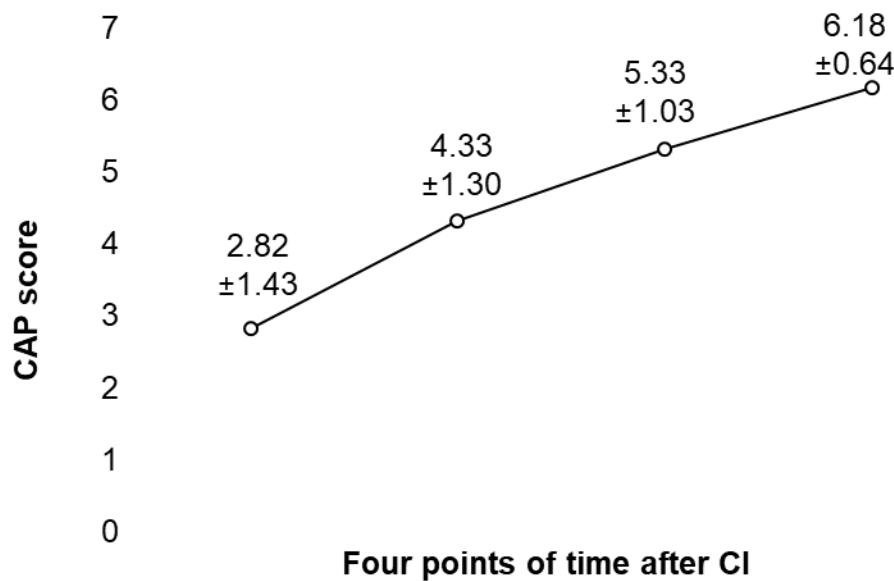
The proposal of the study was approved by Research Ethics Committee of the Ho Chi Minh City Ear-Nose-Throat Hospital (Decision No. 02/QD-HDDD). Informed consent form was used to provide the parents with the purpose and process of the study to make a decision to volunteer for a research study. No personal information was used beyond scientific purposes.

### 3. RESULTS

Table 1 and Figure 1 show the trend on auditory rehabilitation of 39 pediatric patients. Average CAP score at the point 3 months, 6 months, 9 months, and 12 months after CI are 2.82, 4.33, 5.33, 6.18, respectively. The upside trend of the illustrated line proved the improvement of auditory function of the patients. After a year of CI, CAP score is approximate the highest score ( $6.18 \pm 0.64$ ).

**Table 1** CAP score after cochlear implantation, n (%)

CAP score	Point of time			
	3 months	6 months	9 months	12 months
0	1 (2.56)	-	-	-
1	5 (12.82)	-	-	-
2	8 (20.51)	2 (5.13)	-	-
3	19 (48.72)	9 (23.08)	-	-
4	2 (5.13)	11 (28.21)	10 (25.64)	-
5	2 (5.13)	12 (30.77)	12 (30.77)	5 (12.82)
6	-	1 (2.56)	11 (28.21)	22 (56.41)
7	2 (5.13)	4 (10.26)	6 (15.38)	12 (30.77)



**Figure 1** Average CAP score after cochlear implantation, mean (SD)

CAP score at one year after CI is shown in the Table 2. As could be seen, average CAP score of patients over three ( $6.40 \pm 0.51$ ) is higher than those under three ( $6.04 \pm 0.69$ ). In the group of patients over three, there is no case with score under 6, while over 20% of patients fewer than 3 have a score at 5. Overall, in two age groups, patients are almost rehabilitated to the normal condition.

**Table 2** CAP scale at 12 months after CI by age groups

Age group	CAP score, n (%)							Average score, (SD)	mean
	0	1	2	3	4	5	6	7	
≤3	-	-	-	-	-	5 (20.83)	13 (54.17)	6 (25.00)	$6.04 \pm 0.69$
>3	-	-	-	-	-	-	9 (60.00)	6 (40.00)	$6.40 \pm 0.51$

Influence of number of cochlear and number of hours on classroom on CAP score are shown in Table 3. As could be seen, patients experienced bilateral CI have a much higher score than those with unilateral implantation. Regarding number of hours on classroom, there are no significant differences between two groups. Patients in classroom less than five hours a week enhance the CAP score from 3.13 at the third month to 6.20 at the twelfth month. Similarly, patients in classroom more than five hours a week also improve their CAP score from 3.63 at the third month to 6.16 at the twelfth month.

**Table 3.** CAP score by number of cochlear and number of hours on classroom

		Average CAP, mean±SD			
		3 months	6 months	9 months	12 months
Number of cochlear	Unilateral	2.91±1.65	4.26±1.29	5.22±1.00	6.04±0.64
	Bilateral	2.68±1.08	4.44±1.36	5.50±1.10	6.38±0.62
Hours on classroom	<5	3.13±1.96	4.73±1.67	4.00±1.24	6.20±0.68
	≥5	2.63±0.97	4.08±0.97	5.29±0.91	6.16±0.64

Another factor that may influence the CAP score is the corporation of the parents. Among 24 patients with five hours or more in the classroom, patients whose parents did not corporate with teachers have the lower score than those who incorporated (table 4).

**Table 4** CAP score 12 months after CI by corporation of the parents, mean (n, %)

Hours on classroom (hours per week)	Corporation	Without corporation
< 5	6.20 (n = 15)	
≥ 5	6.25 (n = 20; 83.33%)	5.75 (n = 4; 16.67%)

#### 4. DISCUSSION

In this study, CAP scale was used to evaluate auditory rehabilitation of pediatric patients. As an input data, all patients were diagnosed to have severe deaf, equivalent to zero score on CAP scale. After CI operation, this study found significant outcomes as follows. Regarding auditory rehabilitation due to CI, all pediatric patients experienced improve their linguistic ability, but with different level. In one year after CI, 100% patients gained the score at least 5, 87.18% gained the score at least 6. This study found the significant increase, mark at each quarter after operation. Before operation, CAP score of all patients was zero, and average CAP at the point three months, six months, nine months, and one year were 2.82, 4.33, 5.33, and 6.18, respectively. In 2020, Min Young Kwak conducted a study on 114 pediatric patients aged from 1 to 13 and found an increasing trend at each quarter. CAP at the point three months, six months, and one year were 2.30 4.60; 3.40 to 5.30; 4.70 to 5.50, respectively (Kwak et al., 2020). In a study conducted by Hsuan-Yeh Fang et al., (2014) on 84 patients fewer than 5 found that CAP at the point six months and one year were 2.00 and 4.00, respectively.

In comparison with previous studies worldwide, this study found the similar auditory rehabilitation, even show a better outcome. Average CAP of the patients one year after CI in this study was 6.18±0.64, higher than those in study by Bakhshaee et al., (2007)- (5.34) and by Hsuan-Yeh Fang et al., (2014) - (4.00). We supposed two reasons to explain the different. The first factor is the innovation of the technique. There are more than 10 years from the study by Bakhshaee (2007), resulting an improvement on how we operate a CI. Moreover, the quality of cochlear device and rehabilitate classroom, and the corporation of patients' family, are both higher than those in the past. The second factor that may explain the better outcome in this study is the different culture and other social impact on the consideration of parents on their child, which significant associate to his/her rehabilitation.

Regarding the age at CI operation, both age groups (under three vs. over three) experienced an improvement in linguistic ability. Average CAP score one year after CI is 6.04±0.69 in the group under three and 6.40±0.51 in the group over three. In the group of patients who aged under three, 80% gained the final CAP score at least 6. In this age group, the patients are hard to achieve the maximum score, because they cannot use the telephone. Most of them gained the score at 6, which means they understand conversation without lipreading with a familiar talker. In the group of patients who aged over three, there were a higher percentage of patients gained the maximum score, but no more than 50%. Therefore, it can be said that experiencing CI at lower age may achieve the better outcome.

A study by Dettman et al., (2016) on 403 pediatric patients used CNC test to evaluate linguistics rehabilitation, and they found that patients under two achieved better improvement than other age groups. Similarly, studies by Shaofeng Liu et al., (2019) and Guo et al., (2020) used CAP-ASK-WRSs scale and Quianquaian (2020) used CAP-SIR scale found the better rehabilitation on the lower age groups. Overall, this study found the same finding to previous studies on the association between age and auditory rehabilitation. Regarding the number of cochlear used in the operation, patients with unilateral and bilateral CI gained 5 to 7 CAP score. 60.87% patients with unilateral CI and 50% patients with bilateral CI gained the score more than 6. Average CAP one year after CI of patients with bilateral CI (6.38) was higher than patients with unilateral CI (6.04). This finding is similar to those by (Yıldırım Gökay & Yücel, 2021) according to Gregory bilateral CI helps patients improve the auditory ability in noise condition, improve conversation and sound identification. Bradford (Bichey & Miyamoto, 2008) also proved that quality of life is also improved after second cochlear operation.

Regarding the hours in rehabilitation classrooms, previous studies proved that therapeutic classrooms show significant efficacy on auditory improvement after CI. These studies also found that hearing ability, voice realization and music feeling could be better after a course in therapeutic classrooms. In this study, patients spent less hours in therapeutic classrooms (<5 hours/week) gained higher CAP score than the counterparts (>5 hours/week). This opposite result could be explained by the corporation of the parents. A hundred percent of parents of those who spent fewer hours in classroom incorporated with the teacher while this figure in the remained group is only 83.3%. Average CAP score one year after CI in the group of patients with corporate parents is 6.25, much higher than those without corporation (5.75). That is evidence for the fact that therapeutic classroom after CI could improve its efficacy in linguistic rehabilitation if there is corporation between the parents and therapists.

## 5. CONCLUSION

CAP score of pediatric patients tend to increase significantly one year after the operation, almost reach the normal score. Bilateral CI poses higher efficacy than unilateral CI. Hours on rehabilitation classroom and the corporation of the family are also affects the improvement of the patient.

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We thank the participants who were all contributed samples to the study.

### Author contributions

Authors contributed equally in this work.

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### Conflicts of interest

The authors declare that there are no conflicts of interests.

### Ethical approval

The study was approved by Research Ethics Committee of the Ho Chi Minh City Ear-Nose-Throat Hospital (Decision No. 02/QD-HDDD).

### Data and materials availability

All data associated with this study are present in the paper.

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